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**AFOSR Grant No.F49620-93-1-0590**

for the period 30 Sept. 1993 to 29 Nov. 1995

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## **Introduction:**

The research supported by this contract has focused on the concepts and technologies relevant to the production and utilization of high brightness, high current electron beams for generation of high power infrared, visible, ultraviolet, x-ray and gamma ray radiation.

The period reviewed in this report was unusually productive as documented by the titles and texts of the 19 publications generated during this period with AFOSR support.

It is noteworthy that this research has led both to record breaking experimental demonstrations of the accelerator technology required for high power, short wavelength FEL operation (V. N. Litvinenko, Y. Wu, B. Burnham, J. M. J. Madey and S. H. Park, to be published in the proceedings of the 1995 Particle Accelerator Conference), and also the critical theoretical description and analysis of a number of novel low cost approaches to the production of high power XUV, X-ray and gamma-ray radiation.

Special recognition for this record of accomplishment should be accorded to the faculty of the FEL Laboratory, in particular, to Professors Vladimir Litvinenko, Patrick O'Shea, and K. David Straub and to their students.

## **Summary of Research Performed:**

The research performed during this period is summarized in the following publications. Copies of these publications are attached as an appendix to this report:

"Specific Features of Magnet Design for the Duke FEL Storage Ring", B. Burnham, N. Hower, V.N. Litvinenko, J.M.J. Madey, Y. Wu, Proceedings of the 1993 Particle Accelerator Conference, Washington, D.C., pp. 2889-2891.

"Component Technologies for a Recirculating Linac Free-Electron Laser", Vladimir N. Litvinenko, John M.J. Madey and Nikolay A. Vinokurov, Presented on SPIE's International Symposium OE/LASE '94, Technical Conference 2121 "Laser Power Beaming", Los Angeles, CA., January 27-28, 1994.

"mm-Wave Isochronous FEL and Hard X-Ray Inverse Compton Source at Duke Storage Ring", V.N. Litvinenko, Y. Wu, B. Burnham, G. Barnett, J.M.J. Madey, Nucl. Inst. and Meth in Phys. Res A 358 pp. 345-348, 1995.

"Performance of Achromatic Lattice with Combined Function Sextupoles at Duke Storage Ring", V.N. Litvinenko, Y.Wu, B. Burnham, J.M.J. Madey, and S.H. Park, Presented at 1995 Particle Accelerator Conference, Dallas, Texas, May 1-5, 1995.

"Application of Precision Magnetic Measurements for Control of the Duke Storage Ring" B. Burnham, V.N. Litvinenko, Y.Wu, Presented at the 1995 Particle Accelerator Conference, May, 1-5, Dallas Texas.

"Picosecond, tunable, high brightness hard X-ray inverse Compton source at Duke storage ring", V.N. Litvinenko, Y. Wu, B. Burnham, G. Barnett, J.M.J. Madey, SPIE '95 2521-02, 11 Pages, July 1995.

"High Peak Pulse Power Operation of the OK-4/Duke XUV FEL", Vladimir N. Litvinenko, Bentley Burnham, John M.J. Madey, Ying Wu, SPIE '95 2521-08, 12 Pages, July 1995.

"High Power Inverse Compton  $\gamma$ -Ray Source at the Duke Storage Ring", Vladimir N. Litvinenko and John M.J. Madey, SPIE '95, Vol. 2521, pages 2521-07, August 1995.

"Short-wavelength light sources at Duke storage ring", V.N. Litvinenko, G.A. Barnett, B. Burnham, N. Hower, L. Johnson, J.M.J. Madey, Y.Wu, SPIE '95, Vol. 2522, pages 2522B-49, August 1995.

"Giant Laser Pulses in the Duke Storage Ring UV FEL", V.N. Litvinenko, B. Burnham, Y.Wu, J.M.J. Madey, Nucl. Inst. and Meth in Phys. Res A 358, pp. 334-337, 1995.

"Expected Performance of the mm-Wave Isochronous FEL at the Duke Storage Ring", V.N. Litvinenko, Y.Wu, B. Burnham, J.M.J. Madey, Nucl. Inst. and Meth in Phys. Res A 358, pp. 349-352, 1995.

"Dynamics of the Duke Storage Ring UV FEL", V.N. Litvinenko, B. Burnham, Y.Wu, J.M.J. Madey, Nucl. Inst. and Meth in Phys. Res A 358, pp. 369-373, 1995.

"Duke Storage Ring UV/VUV FEL: Status and Prospects", V.N. Litvinenko, B. Burnham, J.M.J. Madey, S.H.Park, Y. Wu, Presented at 17th International FEL Conference, 8/21-25, 1995.

"Microbunching in Storage Ring FELs", B. Burnham, V.N. Litvinenko, J.M.J. Madey, Y. Wu, Presented at Microbunch Workshop, Brookhaven National Lab, Sept. 28-30, 1995.

"In-House Repair of a 30 Megawatt, S Band Klystron", R. Sachtschale, P.G. O'Shea, M. Ponds, G. Swift, , FEL Laboratory, 1995.

"Picosecond pump-probe using an FEL and a synchrotron source", K.D. Straub, J.M.J. Madey, P. O'Shea, V. Litvinenko, E. Szarmes, G. Barnett, SPIE, Vol. 2522, pp. 468-472, 1995..

"The Duke Storage Ring Control System", Y. Wu, B. Burnham, V.N. Litvinenko, FEL Laboratory, 1995.

"RF Phasing of the Duke Linac", Ping Wang, Nelson Hower, Patrick O'Shea, FEL Laboratory, 1995.

"Development of a Modular and Upgradeable Fast Kicker Magnet System for the Duke Storage Ring", R.J. Sachschale, C. Dickey, P. Morcombe, FEL Laboratory, 1995.

#### **Future Research:**

The principal thrusts of the research supported by this grant will continue the directions established in the first two years of this program. In particular, it is anticipated that the OK-4 FEL system will be brought into operation prior to the end of the next contract year. This system will test not only the analytical predictions of performance for this high performance FEL system in the ultraviolet region, but also provide an important experimental test of the theory for gamma ray production through the inverse-Compton scattering mechanism described in the appendices (V. N. Litvinenko and J. M. J. Madey, SPIE '95, Vol. 2522, page 49).